HARPER, KELLY L., M.A. Individual Differences in Perfectionism Predicting Effort (2015)
Directed by Dr. Kari Eddington. 64 pp.

The current study investigated whether individual differences in perfectionism predicted changes in effort across two tasks. Effort is conceptualized as motivational intensity and is measured by autonomic reactivity (Gendolla & Wright, 2009). Past research suggests a possible relationship between two domains of perfectionism (socially prescribed perfectionism [SPP] and self-oriented perfectionism [SOP]) and motivation intensity. On a task that increased in difficulty, it was hypothesized that SPP would interact with the task to predict cardiac variability. People high on SPP would withdraw effort as the task increased in difficulty compared to people low on SPP. In contrast, it was hypothesized that people high on SOP would increase effort as the task increased in difficulty compared to people low on SOP. Furthermore, on an unfixed task with monetary incentives, SPP was hypothesized to predict no change in effort whereas SOP was hypothesized to predict increased effort. Participants ($N$ = 111) completed an attention task with three difficulty levels and an unfixed, incentive task. Multi-level models were used to test whether SPP and SOP interacted with these tasks to explain autonomic variability. Overall, participants showed a negative linear trend of parasympathetic activation and a negative quadratic trend of sympathetic activation as the attention task got more difficult. Furthermore, participants showed both sympathetic and parasympathetic activation during the unfixed, incentive task. Individual differences in perfectionism did not interact with task difficulty or time during the unfixed task to predict cardiac reactivity. These findings draw attention to the importance of

physiological measurement of effort. Past research suggests perfectionism predicts performance outcomes, however, the current study suggests this may not be indicative of differences in effort.

# INDIVIDUAL DIFFERECES IN PERFECTIONSIM PREDICTING EFFORT

by

Kelly L. Harper

A Thesis Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro
2015

Approved by

______________________________
Committee Chair

APPROVAL PAGE

This thesis written by KELLY L. HARPER has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair ______________________________

Committee Members ______________________________

______________________________

______________________________

______________________________
Date of Acceptance by Committee

______________________________
Date of Final Oral Examination

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

# CHAPTER I

# INTRODUCTION

Effort, which is conceptualized as the intensity aspect of motivation (Gendolla & Wright, 2009) is defined as the mobilization of energy resources to perform behavior to satisfy a motive (Gendolla & Wright, 2009). Brehm's motivational intensity theory follows a value-expectancy concept and expands on the assumption that behavior is directed by the energy conservation principle (Brehm, Wright, Solomon, Silka, & Greenberg, 1983; Brehm & Self, 1989). Goal attainment requires energy to be exerted to overcome obstacles and strive for the goal but when too much energy is used it is depleted. Therefore, people conserve energy to decrease the probability of energy depletion (Gendolla & Richter, 2010). People typically do not extend more effort than what is needed for the task at hand because extra effort would be futile. Brehm's motivational intensity theory extends the energy conservation theory by stating that the level of exerted effort is defined by importance of success and the difficulty of the behavior that is needed to achieve the goal (Brehm et al., 1983; Brehm & Self, 1989). Specifically, effort is typically low for easy tasks and as a task becomes more difficult, more effort is exerted. Also, as a task continues to increase in difficulty there is a point where effort declines because the task is perceived as impossible or the importance of success does not justify the amount of energy needed for success (Gendolla & Richter, 2010).

Based on Brehm's motivational intensity theory (Brehm & Self, 1989) effort may be related to intrinsically- versus extrinsically-motivated goals at least in part due to emotional investment. Goals that are pursued for intrinsic reasons (self-selected and self-imposed) are more strongly associated with positive outcomes (Sheldon & Kasser, 1998; Sheldon & Kasser, 1995) whereas pursuit of extrinsic goals (imposed by others) is less related to positive well-being (Kasser & Ryan, 1996). Thus, under conditions of extrinsic motivation, people may be more ambivalent towards their goal (and its outcome) and therefore may put less effort, and less sustained effort, into achieving the goal because it is not inherently important. In contrast, if a person has intrinsic motivation, they may be more likely to persist or try harder to obtain a goal due to emotional investment in the goal.

**Measurement of Effort**

There are multiple ways effort has been measured in past research including self-report, achievement and task performance, persistence, and physiological measures. Self-report measurements are used widely but are sensitive to demand characteristics and self-presentational issues (Blascovich, Vanman, Mendes, & Dickerson, 2011). Achievement, which is also a commonly used measurement of effort (Accordino, Accordino, & Slaney, 2000; Bieling, Israeli, Smith, & Antony, 2003; Stoeber & Rambow, 2007), does not necessarily reflect the amount of effort required to perform a task. Research shows that people who are gifted at a task will perform with high accuracy or achievement without having to put much effort into the task whereas people who are not as gifted must put in more effort to perform equally or worse (see Wright & Kirby, 2001, for review). Finally, time spent on a task or persistence has also been used to measure effort (Martin, Ward, Achee, & Wyer, 1993; Muraven & Slessareva, 2003) although similar to the difficulty with measuring achievement, the intensity of effort is unknown. For example, a person could be putting a small amount of effort into a task but continue putting effort in over a long period of time. Furthermore, it is difficult to measure change in the amount of effort exerted or at multiple time points within a timeframe when effort is measured by persistence or achievement. It would be difficult for people to retroactively report the amount of effort they engaged at different time points of a task and, as mentioned previously, these changes may not be sensitive to changes in achievement or accuracy.

Another way to measure effort is by examining physiological changes during tasks. There is collective evidence that cardiovascular activity reflects not only physical effort but also cognitive effort (Wright, 1996; Wright & Kirby, 2001). Cardiovascular reactivity is a type of physiological measurement of effort that involves the integration of Brehm's motivational intensity theory and Obrist's (1981) active coping approach to connect effort mobilization to physiological outcomes (Wright, 1996). According to Obrist's (1981) active coping approach, decreasing effort on a task is called *passive coping* or *disengaged coping* and continued or increased effort is called *active coping*. Research has shown that experienced task difficulty and the importance of success have a joint effect on physiological measures of effort mobilization (Wright, 1996) and increased cardiac reactivity is broadly representative of active coping and decreased cardiac reactivity is broadly representative of disengaged coping (Silvia, Jones, Kelly, & Zibaie, 2011).

In addition to Wright's active coping approach (Wright, 1996) which focuses primarily on sympathetic measures of cardiac reactivity, researchers have also examined how parasympathetic activation is related to self-regulation and cognitive control (see Segerstrom, Hardy, Evans, & Winters, 2012 for a review). Self-regulation is defined as the ability to control one's emotions, inhibit impulses, persist on tasks, and make executive decisions. Self-regulation has an inconsistent relationship with parasympathetic activation. Some research indicates that increased heart rate variability (HRV), which is a measure of parasympathetic variability, is related to higher self-regulation (Segerstrom & Solberg Nes, 2007; Luft, Takase, & Darby, 2009). However, other research indicates that decreased HRV is related to increased self-regulation (Movius & Allen, 2007; Hansen, Johnson, & Thayer, 2003). In addition to the inconsistent findings with parasympathetic activation and self-regulation, the literature does not map neatly onto the effort literature and few studies have examined both sympathetic and parasympathetic activation as a measure of effort. Silvia and colleagues (2013) found that grit, a personality construct that captures the ability to sustain effort towards long-term goals, was related to coactivation of the sympathetic and parasympathetic branches during a mental effort task. This finding draws attention to the importance of looking at both branches of the autonomic nervous system during mental tasks.

## Physiological Measures

### Sympathetic

There are multiple measures of cardiovascular reactivity that have been used to assess effort. The majority of these measures of cardiovascular reactivity capture sympathetic activation including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and preejection period (PEP). Historically, SBP has been prominently used in the relatively small effort literature. However, PEP is a more contemporary measure of beta adrenergic sympathetic activation and research suggests it may be more precise than SBP (Ritcher & Gendolla, 2009). Richter, Friedrich, and Gendolla (2008) showed evidence for the validity of PEP as a measure of effort. In their study examining PEP reactivity and task difficulty, results supported Wright's (1996) model; when task success was possible, PEP values decreased which indicates increased sympathetic activation in proportion to increases in task difficulty. In contrast, when task success was impossible, PEP values were high indicating decreased sympathetic activation. Another way to measure sympathetic reactivity is RZ which is the interval between the R wave and the dZ/dt peak. Traditionally, the B point used to calculate PEP is estimated using RZ, therefore measuring RZ provides a similar and possibly more valid measurement of sympathetic cardiac reactivity in addition to PEP (Lozano et al., 2007). However, RZ has not been used to measure mental effort in the literature therefore it cannot be used as a standalone measure of sympathetic reactivity.

**Parasympathetic**

Within the parasympathetic literature, the root mean square of successive differences (RMSSD) is often used to measure HRV (Segerstrom & Solberg Nes, 2007; Hansen, et al., 2003). RMSSD is a measure of the time between successive heart beat intervals and represents heart period variability (Bernston, Lozano, & Chen, 2005) and is sensitive to short term changes in heart rate variability. Another measure of parasympathetic activity commonly used to measure self-regulation is respiratory sinus arrhythmia (RSA) (Movius & Allen, 2007). RSA is a measure of rhythmic change in between heart beat periods that is related to respiration and is conceptualized as a measure of vagal control (Berntson, Cacioppo, & Quigley, 1993).

There are several strengths of using physiological measurement of effort compared to self-report, as discussed in Blascovisch et al. (2011). First, physiological measures have temporal markers and therefore are more precise measurements for specific time points in a study, and physiological measures do not rely on introspection for either prospective or retrospective self-report. Second, they are sensitive to changes that people often are unaware of such as changes in mental states. Finally, physiological measurement is less susceptible to demand characteristics and decreases problems with participant self-presentation.

**Perfectionism and Motivation**

Research on the relationship of perfectionism with goal directed behavior suggests that individual differences in perfectionism may be related to effort. Perfectionism has been examined in relation to goal pursuit and extrinsic/intrinsic motivation as a possible moderator of the relationship between motivation and emotional outcomes. Individual differences in perfectionism may be related to emotional investment in goals. Thus, according to Brehm’s motivational intensity theory, perfectionism may influence the amount of effort put into goal pursuit. Although perfectionism has been measured in different ways, it is widely recognized that perfectionism is a multi-dimensional construct (Dunkley, Blankstein, Halsall, Williams, & Winkworth, 2000;

Frost, Heimberg, Holt, Mattia, & Neubauer, 1993; Hewitt & Flett, 1991a). Self-oriented perfectionism (SOP) is defined as perfectionistic behaviors and standards that are self-imposed (Hewitt & Flett, 1991a). In contrast, socially prescribed perfectionism (SPP) is defined by the need to meet standards and objectives that are set by others and the perception that others have unrealistic expectations for them (Hewitt & Flett, 1991a).

SPP is conceptualized as maladaptive and there is ample evidence in the literature to support this conceptualization. For example, SPP and related constructs, such as evaluative concerns and self criticism which are latent variables defined in part by SPP (Stoeber, Hutchfield, & Wood, 2008; Dunkley, Zuroff, &Blankstein, 2003), are related to risk for depression and anxiety (Hewitt & Flett, 1991b), hopelessness (O'Connor & O'Connor, 2003) high daily stress, low self-efficacy, daily negative affect (Dunkley et al., 2003) and avoidant coping styles (Dunkley et al., 2000; Dunkley et al., 2003; Mills & Blankstein, 2000; Weiner & Carton, 2012). SOP and related constructs (i.e., personal standards and perfectionistic striving which are latent variables defined in part by SOP; Stoeber et al., 2008; Dunkley et al., 2003) have been conceptualized as adaptive forms of perfectionism but empirical support is mixed. SOP and related constructs have been associated with positive domains of well-being such as personal growth (Chang, 2006), adaptive coping (Dunkley et al., 2000; Flett, Russo, & Hewitt, 1994; Weiner & Carton, 2012), and high self-efficacy (Stoeber et al., 2008). In contrast, other studies suggest that SOP and related constructs are associated with increased risk for depression (Hewitt, Flett, & Ediger, 1996), hopelessness (O'Connor & O'Connor, 2003), and increased negative affect after negative feedback on a task (Besser, Flett, & Hewitt, 2004).

Although SOP has been associated with depression, the association between depression and SOP (*r* = .02 -.32) is not as large as the association between depression and SPP (*r* = .38-.45) (Hewitt, et al., 1996; Flett, Galfi-Pechenkov, Molner, Hewitt, & Goldstein, 2012; Eddington, 2013). The inconsistency in associations between SOP and emotional outcomes suggests that SOP may be adaptive in some situations but not in others. For instance, Hewitt, Flett, and Ediger (1996) found that SOP interacted with achievement to predict depression such that people high on SOP who also had high achievement were more likely to have high depression ratings. These findings suggest there is a motivational component that may explain why individual differences in perfectionism lead to different emotional outcomes.

In order to further elucidate the mixed perfectionism findings, Eddington (2013) used a motivational framework to examine how perfectionism (SPP and SOP) correlated with emotional consequences of goal pursuit. Results showed that higher SOP was associated with stronger emotional consequences in response to goal success or failure including feelings of happiness, pride, and sadness. In contrast, SPP was not correlated with emotions associated with goal success or failure. These findings indicate that people who are high on SPP may not experience goal-related emotional consequences as robustly as people who are high on SOP which may indicate differing levels of emotional investment in goals. Consistent with this conceptualization, research has shown that SPP is associated with extrinsically-motivated goals and SOP is associated with intrinsically-motivated goals (Miquelon, Vallerand, Grouzet, & Cardinal, 2005). As mentioned above, intrinsic goals are more strongly associated with positive emotional outcomes than extrinsic goals (Sheldon & Kasser, 1998; Sheldon & Kasser, 1995; Kasser & Ryan, 1996; Burton, Lydon, D'Alessandro, & Koetsner, 2006). Therefore, people with extrinsically-motivated goals may be less invested in their goals and therefore less likely to experience positive emotional consequences from goal progress or attainment. In addition, extrinsic motivation may lead individuals to be more likely to disengage from goals due to decreased investment in goals.

**Perfectionism and Effort**

Overall, research suggests that perfectionism moderates the relationship between goal pursuit and emotional outcomes. Although effort is implied to be fundamental for goal pursuit, research on perfectionism and effort has been limited in the past and, importantly, has only focused on effort as measured by performance outcomes, accuracy, or time spent practicing a trade. Performance outcomes demonstrate that people high on SOP and related constructs tend to perform better on academic exams and GPA (Accordino, Accordino, & Slaney, 2000; Bieling et al., 2003; Stoeber & Rambow, 2007), aptitude tests (Stoeber & Kersting, 2007), Stroop color-naming task (Kobori & Tanno, 2005), and music competitions (Stoeber & Eismann, 2007) than people low on SOP and related constructs. SOP and related constructs have also been positively correlated with effort as measured by time spent studying (Bieling et al., 2003; Mills & Blankstein, 2000), time spent practicing musical instruments (Stoeber & Eissman, 2007), and persistence (Longbottom, Grove, & Dimmock, 2010). SPP and related constructs have not shown a consistent relationship with performance (Stoeber & Otto, 2006) or accuracy (Stoeber, Chesterman, & Tarn, 2010). A study by Stoeber and Eissman (2007) investigated how perfectionistic striving (a latent variable defined in part by SOP) and perfectionistic concern (a latent variable defined in part by SPP) were related to motivation, effort, achievement, and distress in young German musicians. They found that perfectionistic striving was associated with intrinsic motivation, higher effort (measured by time spent practicing), and higher achievement, whereas perfectionistic concern was associated with extrinsic motivation and higher distress.

**Perfectionism and Cardiovascular Reactivity**

To date there has only been one study that examined perfectionism and cardiac reactivity together. Besser, Flett, Hewitt, and Guez (2008) looked at how SPP and SOP interacted with objective task performance, confidence, and manipulated feedback (positive vs. negative) in predicting HR, SBP, and DBP. More specifically, the study used an attention task that required the participant to answer as quickly and as accurately as possible. The participant was shown a set of either three boxes (easy level) or six boxes (difficult level). A white rectangle would appear in one of the boxes and the participant had to press the corresponding key to indicate which box the rectangle appeared in. Results showed that people high on SPP and low in self confidence had higher HR when presented with negative feedback. Furthermore, people high on SOP who had low performance had higher HR when presented with positive feedback. In predicting SBP, SOP interacted with objective performance and SPP interacted with feedback. Therefore people high on SOP had increased SBP when performance on the task was low. Furthermore, people high on SPP had increased SBP when they received negative feedback after the task. There were no effects for SPP or SOP in predicting DBP. This study suggests that people high on SOP may be more sensitive to actual performance whereas people high on SPP are sensitive to feedback.

Although this study is informative and shows evidence of a differential relationship between individual differences in perfectionism (i.e., SPP and SOP) and cardiac reactivity, there are a few limitations. This study was not measuring mental effort, therefore physiological measurements were not collected during task performance but only prior to the task and after feedback. Also, the study did not look at how task difficulty may interact with perfectionism in predicting cardiac outcomes. Finally, the study used only HR, SBP, and DBP -measures of sympathetic activation only- whereas it may be important to look at both sympathetic and parasympathetic activation.

**Current Study**

The purpose of the current study was to further investigate the relationship of these two domains of perfectionism (SOP and SPP) with motivation by looking at physiological effort. These two domains of perfectionism may have different motivational underpinnings. It has been theorized that people high on SPP have extrinsically-motivated goals and therefore are less emotionally invested in their goal success. This suggests that individuals high on SPP may be more likely to give up on or disengage effort from the goal. In contrast, people high on SOP have intrinsically-motivated goals and therefore may be more invested and more likely to continue exerting effort towards their goals. Physiological effort, which can be an indicator of importance of success, may be a better method of measuring of the association between individual differences in perfectionism and goal pursuit than self-report or performance outcomes (Blascovisch et al., 2011).

The current study examined physiological effort in people varying in levels of perfectionism during the course of two tasks: the d2 task which was an attention task that increased in difficulty and the parity task which was an unfixed task with a monetary incentive. Tasks with unfixed difficulty, which means a person can go at his/her own pace and are not given instructions about the standard of performance, are useful for studying how important task success is to a person based on Brehm's motivational theory (Wright, Killebrew, & Pimpalapure, 2002; Brehm & Self, 1989). Moreover, tasks with incentives are able to measure the value of the reward in relation to the amount of effort put into the task (Richter & Gendolla, 2009) and certain factors such as grit and depression can interact with incentives to predict higher or lower levels of effort (Silvia et al., 2013; Brinkmann, Schupbach, Ancel Joye, & Gendolla, 2000). The primary aim of the current study was to examine whether the two domains of perfectionism (SPP and SOP) predict decreased effort (indicated by a decrease in sympathetic activation as defined by higher PEP and RZ values) or increased effort (an increase in sympathetic activation as defined by lower PEP and RZ values) as a function of task difficulty or monetary incentives. As a secondary outcome, parasympathetic activation was also measured to examine whether individual differences in perfectionism predicted increased self-regulation indicated by higher levels of RSA and RMSSD (see Segerstrom et al., 2012 for a review) and whether both branches of the autonomic nervous system were activated across both tasks. Physiological measurements were taken during baseline, during three different levels of the d2 task (easy, medium, and difficult), and during the parity task.

Across both tasks, to the extent that they involve higher intrinsic motivation, SOP was hypothesized to predict a decrease in PEP and RZ values indicating high importance of success on the tasks. In contrast, it was predicted that SPP, to the extent that it involves primarily extrinsically motivated goals and less goal investment, would be associated with an increase in PEP and RZ values- indicating withdrawing effort - as the d2 task increases in difficulty. With regard to the parity task, although people high on SPP may be more likely to pursue extrinsically-motivated goals, this relationship does not necessarily indicate that people high on SPP will pursue these goals with greater motivational intensity (i.e., effort). Furthermore, people high on SPP tend to be sensitive to recognition from others as reward (Mills & Blankstein, 2000) and consequently they may not be as reactive to monetary incentives, which lack a "social evaluative" component. Therefore, as an exploratory hypothesis it was predicted that SPP would show a decreased sensitivity to the monetary incentives and would not predict change in effort. Furthermore, across both tasks, it was hypothesized that SPP would not be related to performance outcomes whereas SOP would predict the percent answered correctly in both tasks based on previous research on task performance (Stoeber et al., 2010; Kobori & Tanno, 2005). Finally, as an exploratory hypothesis SOP was also hypothesized to interact with time to predict increased RSA and RMSSD indicating a coactivation profile and increased self-regulatory control (Segerstrom et al., 2012) similar to the finding related to grit and HRV (Silvia et al., 2013).

# CHAPTER II

# METHODS

## Participants

Participants (N = 111) were female undergraduate students who received partial credit for an introductory to psychology class for their participation. From the initial sample, 10 participants were excluded from all analyses due to taking medication that influences physiology measurements such as antidepressants, antihistamines, and psychostimulants, and two participants were excluded from analyses due to low $Z_o$ scores and low RMSSD values. These outliers were over two standard deviations away from the mean. For the parity task, 98 participants were included; two participants were excluded from analyses because they admitted they did not understand the parity task or performed below chance level which indicates the participant did not understand the task. For the d2 task, 92 participants were included in the d2 task analyses; six participants were excluded because their percent correct on the task indicated they did not understand the task.

Overall, the 98 participants that were included in analyses had a mean age of 18.53 (*SD* = 1.06) and 43.9 % were African American, 44.9% were Caucasian, 6.10% were Asian, 7.1% were Hispanic, 1.0% were Native American, and 2.0% declined to state their ethnicity. The mean body mass index (BMI) was 24.11 (range: 16.82 - 46.51). Every participant signed informed consent and participants were debriefed after the study.

## Measures

### Physiological measurement

Cardiovascular measurements were collected with a Mindware Bionex hardware system (Mindware, Gahanna, OH), which continuously measured electrocardiogram (ECG) and impedance cardiogram (ICG) signals. ECG was obtained with three electrodes: one placed on the right collarbone, one placed on the left lowest rib, and one placed on the right lowest rib. ICG was obtained with four electrodes. Following standard electrode placement, two electrodes were used as the receiving electrodes and were placed on the front of the participant's body (one placed on the left collarbone horizontal to the jugular notch and one placed at the bottom of the sternum). Two other electrodes were used as the sending electrodes and were placed on the back of the participant's body (one was placed on the back of the neck, 1.5 inches higher than the electrode on the collarbone and one was placed on the back, 1.5 inches lower than the electrode at the bottom of the sternum). ECG and ICG was sampled at 1,000 Hz.

PEP, the time interval between onset of ventricular depolarization and the opening of the aortic valve (Obrist, Light, James, & Strogatz, 1987; Schachinger, Weinbacher, Kiss, Ritz, & Langewitz, 2001), was calculated by the difference between the ECG Q-point, which is the onset of the ventricular depolarization (Berntson, Lozano, Chen, & Cacioppo, 2004), and the ICG dZ/dt B-point, which represents the left ventricular ejection (opening of the aortic valve; Lozano et al., 2007). Ensemble averages were created by averaging over all of the beats for a 60-second period. This method decreases the influence of single beat fluctuations due to respiration. The difference between the

ECG Q-point and the ICG dZ/dt B-point were then calculated for each ensemble average by the IMP software program (Mindware, Gahanna, OH) (Riese et al., 2003). RZ was calculated by the difference between the ECG R point and the ICG dZ/dt Z-point (Lozano et al., 2007). RSA was computed using spectral methods within respiration frequency. Respiration rate was estimated with the Mindware software by using the ICG $Z_o$ thoracic impedance signal. RMSSD was computed as the root mean square of successive differences between heart periods with the Mindware software.

Sympathetic and parasympathetic cardiac activity was assessed first during a baseline assessment period while participants completed questionnaires, which lasted approximately 5 minutes. Sympathetic and parasympathetic cardiac activity was also measured during task performance at each task difficulty (each task difficulty level lasted 3 minutes) on the d2 task and during the three minutes of parity task. Five 60 second averages were created for the baseline period, three 60 second averages were created for each level of task difficulty for the d2 task, and three 60 second averages were created for the parity task.

**Assessment of perfectionism**

The Multidimensional Perfectionism Scale (MPS; Hewitt, Flett, Turnbull-Donovan, & Mikail, 1991) was used to measure perfectionism. The MPS is a 45-item scale measuring three dimensions of perfectionism: SPP, SOP, and other-oriented perfectionism. Items capture individual differences in perfectionism within these three domains (e.g. “I find it difficult to meet others’ expectations of me”, “One of my goals is to be perfect in everything I do”, “It is very important that I am perfect in everything I attempt", respectively). Items are rated on a 7-point scale from "strongest disagreement" (1) to "strongest agreement" (7) such that higher scores indicate greater perfectionism. Previous studies have shown good internal consistency (Cronbach's α) of these scales in nonclinical samples (SOP $\alpha = 0.88$; SPP $\alpha = 0.75$; Hewitt & Flett, 1991a). Furthermore, the current sample had comparable internal consistency of these scales (SOP $\alpha = 0.80$; SPP $\alpha = 0.87$) to previous samples.

**The d2 task**

Participants completed the computer-based version of the d2 test of attention (Brickenkamp & Zillmer, 1998), which has been used in several previous studies on effort and motivation (Gendolla & Richter, 2005; Gendolla, Richter, & Silvia, 2008; Silvia, McCord, & Gendolla, 2010; Eddington & Foxworth, 2012; Silvia, Moore, & Nardello, 2014). The instructions for the d2 task were to get 90% correct. The d2 task presents a letter *d* or *p* on the computer screen and the letter can have 1, 2, 3, or 4 apostrophes above and below it. Participants had to decide if the picture on the screen is a target, which is a *d* with 2 apostrophes above it, 2 apostrophes below it, or with one apostrophe above and one apostrophe below it, or if the picture is a non-target. Participants were told to press a yellow button if the letter is a d with exactly 2 apostrophes and a blue button for all other items that are non-targets (*d*'s with 1, 3, or 4 apostrophes, and all *p*'s) (see Figure 3). People used their dominant hand to respond and responses were collected with a DirectIN high-speed keyboard (Empirisoft, NY). The d2 task was presented using DirectRT (Empirisoft, NY).

***Manipulation of task difficulty***. Fixed levels of task difficulty were manipulated by varying the response time window for each task trial. In the easy condition, each trial lasted for 2500 ms. In the medium condition, each trial lasted for 1250 ms and in the difficult condition, each trial lasted for 750 ms. In all of the conditions, the picture remained on the screen until the end of the response time window no matter whether a response was selected or not. This prevents people from working at their own pace, which would turn the fixed-difficulty task into an unfixed task (Wright et al., 2002). The timing parameters that were used to determine the task difficulty are based on past research with this task (Gendolla, Ritcher, & Silvia, 2008; Silvia et al., 2010; Silvia et al., 2011). The difficult condition was intended to evoke a range of effort and allow for variability in responses. Responding within the 750 ms time window is challenging but not impossible. Based on past research with this task (Silvia et al., 2011), it is expected that some participants would disengage from the task (reflected in higher PEP values) and others would activate additional effort (reflected in lower PEP values) based on whether the task is important enough to activate additional effort.

The order of task difficulty was set at easy, medium, and then difficult for every participant. The order of task difficulty was not counterbalanced. The primary interest of the current study was to examine within-person patterns of trying and quitting. The purpose of this study was to capture the level of difficulty at which individual differences in perfectionism predict quitting. By counterbalancing the levels it would be obvious when participants engage effort, but less clear when participants show a pattern of engaged and then withheld effort at a specific difficulty level (Silvia, Nusbuam, Eddington, Beaty, & Kwapil, 2014).

**Parity task**

The parity task has been used in previous physiological studies of effort and has been shown useful in studying mental effort (Silvia et al., 2014). The instructions for the parity task specified that every correct answer was worth 3 cents. Money as an incentive has been shown to increase the importance of task success (Franzen & Brinkman, 2015). The parity task is a forced choice task where participants must decide if the parity of two numbers is the same or not. The two numbers are presented on opposite sides of a word (e.g., “8 CHAIR 2”) so the participant must ignore the word in the middle and only focus on the two numbers. The word in the middle of the numbers changed between 12 commonplace nouns such as chair, bench, and boat. The numbers used were 2, 3, 5, and 8. Participants were told to press a yellow button if the letters were the same parity and a blue button if the letters were not the same parity. People used their dominant hand to respond and used the same keyboard as the d2 task. The parity task was an unfixed task which means that people were able to work at their own pace and the stimulus remained on the screen until participants responded. The task lasted for 3 minutes.

**Self-report assessment of task performance**

Participants completed self-report items about task performance after completing the d2 task: “In your opinion, how well did you do on the d2 task?”, “How hard did you try to get 90% right?”, “In your opinion, how well do you think you did compared to other people who completed the task in the study?”, “How important was it to you to get

90% right?”, “In your opinion, how easy or hard was this task?”. Participants completed the following items after completing the parity task: “In your opinion, how easy or hard was this task?”, “In your opinion, how well did you do on the parity task?”. The items were rated on a 7 point Likert scale where “1” is low and “7” is high.

**Procedures**

Participants completed a battery of questionnaires that included the MPS before beginning the d2 task. The questionnaires were completed using MediaLab (Empirisoft, NY). The completion of these questionnaires made up the 5 minute cardiovascular baseline measurement. Participants then completed a set of 22 practice trials to acquaint them with the d2 task. The experiment d2 task began after participants completed the practice trials. The task lasted for 3 minutes in each difficulty level (easy, medium, difficult), and cardiovascular responses were measured continuously and assembled into 60 second long averages. After the d2 task, participants completed self-report questions about the task and a few other brief questionnaires not used in the current study. During the completion of the second grouping of questionnaires, a second cardiovascular baseline was established. The second baseline was not used in analyses, but was used to allow participants to return to baseline after the d2 task. After the completion of the second group of questionnaires, participants were given instructions on how to complete the parity task and were informed they would earn 3 cents for every correct item they answer on the parity task. Participants then completed 3 minutes of the parity task. Afterwards, participants were debriefed and thanked for their participation.

# CHAPTER III

# ANALYSES

Multilevel models were used to examine the within-person main effects and cross level interactions. In the models for the d2 task, task difficulty (time) was a Level 1 within-person variable. The three levels of task difficulty were coded using polynomial regression coding for linear and quadratic trends. The linear trend was coded (-1, 0, 1) and the quadratic trend was coded (1, -2, 1). Both linear and quadratic trends were included in the same models. In the models for the parity task, baseline (coded 0) and task (coded 1) were included as Level 1 within-person variables. Respiration rate was also included as a Level 1 within-person variable for models estimating RSA and RMSSD. Perfectionism scores for SPP and SOP and baseline physiological values were the Level 2 between-person variables. SPP and SOP were centered in all of the models and were included in a single model to estimate their unique effects and evaluate whether SPP is a stronger predictor of the slope of autonomic variability and task difficulty. The models were estimated using Mplus 7.

The main effect of the Level 1 within-person variables predicting effort was analyzed to test whether the tasks predicted effort. These results were interpreted using a cutoff of $p < .05$. To examine whether there was a cross-level interaction between the Level 2 variables (SPP and SOP) and the Level 1 variables, the slope of Level 1 variables (linear and quadratic trends for the d2 task; time for the parity task) and autonomic variability were regressed on SPP and SOP. These models showed whether the Level 2 variables predicted the relationship between autonomic variability and task.

Linear regression models were completed to analyze whether SPP and SOP predicted percent correct on the d2 task (within task difficulty level) and total correct on the parity task. Regression was also completed to test whether SPP and SOP predicted task self-report items. These results were interpreted using a cutoff of $p < .05$.

## CHAPTER IV

## RESULTS

The mean, standard deviations and correlations for baseline autonomic measures and the intraclass correlations for PEP, RZ, RSA, and RMSSD are presented in Table 1. The mean level of SPP was 58.51 (*SD* = 11.61) and the mean level of SOP was 68.65 (*SD* = 18.57).

### Baseline

SOP significantly predicted baseline level of PEP (b = -2.43, *SE* = 1.16, *p* = 0.04). However, SPP did not predict baseline level of PEP (b = =2.06, *SE* = 1.46, *p* = 0.16). This indicates that people with higher levels of SOP had lower PEP values during the baseline period. Moreover, neither SPP nor SOP predicted baseline RZ (SPP: b = 3.32, *SE* = 2.14, *p* = 0.12; SOP: b = -2.86, *SE* = 1.78, *p* = 0.11), RSA (SPP: b = 0.12, *SE* = 0.17, *p* = 0.48; b = -0.21, *SE* = 0.14, *p* = 0.14), or RMSSD (SPP: b = 5.49, *SE* = 4.02, *p* = 0.17; SOP: b = -3.67, *SE* = 3.65, *p* = 0.32).

### d2 Task

#### Sympathetic reactivity

***Within-person main effect.*** To examine whether people initially engaged effort in the d2 task, PEP and RZ were regressed on the within-person main effect of change from baseline to the easy level of the task. The within-person main effect of change from baseline to task did significantly predict PEP and RZ (see Table 2). However, these findings are in the opposite direction than expected; people withdrew effort during the easy level of the task.

The within person main effect of the linear trend predicting PEP was not significant (b = -0.04, *SE* = 0.18, *p* = 0.80). However, the within person main effect of the quadratic trend predicting PEP was marginally significant (b = -0.17, *SE* = 0.09, *b* = 0.07). Although the within person main effect of the linear trend predicting RZ was not significant (b = 0.01, *SE* = 0.29, *p* = 0.97), the within person main effect of the quadratic trend predicting RZ was significant (b = -0.30, *SE* = 0.12, *p* = 0.01). These findings indicate that people withdrew effort on the easy task, further decreased effort on the medium task, and were trying harder during the difficult task level.

***Cross level interaction.*** The regression coefficients, standard errors, and p-values for the cross level interaction models of SPP and SOP predicting sympathetic activity as the d2 task increased in difficulty are presented in Table 3. Neither SPP nor SOP significantly interacted with the linear trend of PEP and task difficulty. Similarly, neither SPP nor SOP significantly interacted with the quadratic trend of PEP and task difficulty. Likewise, SPP and SOP did not significantly interact with the linear or quadratic trend of RZ and task difficulty. These results suggest that individual differences in perfectionism did not interact with task difficulty to predict increases or decreases in sympathetic activation.

**Parasympathetic reactivity**

***Within-person main effect.*** The within-person main effect of change from baseline to the easy level of the task significantly predicted RSA and RMSSD (see Table

4). These findings suggest that people showed a decrease in parasympathetic activation from baseline to the beginning of the task.

There was a significant within-person main effect of the linear trend predicting RSA (b = -0.10, $SE$ = 0.02, $p$ < 0.00). In addition, the within-person main effect of the quadratic trend predicting RSA was approaching significance (b = 0.02, $SE$ = 0.01, $p$ = 0.08). There was a significant within-person effect of the linear trend predicting RMSSD (b = -2.07, $SE$ = 0.64, $p$ < 0.00). However, the within-person effect of the quadratic trend predicting RMSSD was not significant (b = 0.27, $SE$ = 0.25, $p$ = 0.28). These results suggest that people's RSA and RMSSD values decreased as the difficulty increased.

***Cross level interaction.*** See Table 5 for the regression coefficients, standard errors, and p-values of the cross-level interaction of SPP and SOP predicting parasympathetic values as the d2 task increased in difficulty. Results showed that SPP did not significantly moderate the linear or quadratic trend of task difficulty and RSA. Similarly, SOP did not significantly moderate the linear or quadratic trend of task difficulty and RSA. SOP also did not significantly interact with the linear or quadratic trend of task difficulty and RMSSD. Interestingly, the interaction of SPP with the linear trend of task difficulty and RMSSD approached significance. Therefore, as people got higher on SPP, the slope between RMSSD and task difficulty became less steep (see Figure 2). SPP did not significantly interact with the quadratic trend of task difficulty and RMSSD.

***d2 performance.*** SOP significantly predicted the percent correct on the difficult task level so that higher SOP scores predicted better accuracy on the difficult level of the d2 task. Neither SOP nor SPP predicted accuracy on the other levels of the d2 task (see Table 6 for regression of accuracy on SPP and SOP).

On the self report items participants completed about the d2 task, SOP significantly predicted how participants thought they performed compared to others, ratings of task importance, and ratings of how well participants thought they performed. SPP did not predict ratings on the self-report measures. See Table 6 for the regression coefficients, standard errors, and p-values of the regression of self-report items on SPP and SOP.

## Parity Task

### Sympathetic reactivity

***Within-person main effect.*** To examine whether participants were engaging effort in the parity task, PEP was regressed on time; results indicated the within-person main effect of PEP on time was significant (b = -1.26, $SE = 0.53$, $p = 0.02$). The main effect of time in predicting RZ was also significant (b = -2.62, $SE = 0.95$, $p = 0.01$). Therefore, people increased sympathetic activation from baseline to task.

***Cross level interaction.*** Neither SOP nor SPP significantly moderated the relationship between PEP and time from initial baseline to task (see Table 7). Similarly, SPP and SOP did not moderate the slope of RZ and time (see Table 7).

These results indicate that overall participants were engaging in the task and increasing effort (as evidenced by decreased PEP and RZ values), however, individual differences in perfectionism did not moderate how much effort was engaged in the task.

### Parasympathetic cardiac reactivity

***Within person main effect.*** The within-person main effect of time significantly predicted RSA (b = 0.19, *SE* = 0.07, p = 0.01). The main within-person effect of time also significantly predicted RMSSD (b = 8.10, *SE* = 1.89, $p < 0.00$). These results suggest that people increased in RSA and RMSSD levels from baseline to task.

***Cross level interaction.*** Neither SPP nor SOP significantly interacted with time to predict RSA or RMSSD (see Table 7).

***Parity performance.*** Neither SPP nor SOP significantly predicted accuracy on the parity task (see Table 8). In terms of subjective self-report items, SPP significantly predicted ratings of how hard the task was. However, SOP did not significantly predict ratings of how hard the task was. Furthermore, neither SPP nor SOP predicted ratings of how well participants thought they performed on the task. See Table 8 for the regression coefficients, standard errors, and p-values for regression of self-report items on SPP and SOP.

# CHAPTER V

# DISCUSSION

The purpose of the current study was to examine how individual differences in perfectionism are related to effort measured by autonomic reactivity using two separate tasks. Contrary to predictions, perfectionism did not moderate the relationship between task difficulty and task incentive to predict sympathetic activity which is the primary and most robust measurement of effort. The current study did find a general decrease in sympathetic values indicating increased effort on the parity task, suggesting that people increased effort from baseline to task, but this relationship was not moderated by SPP or SOP. In terms of parasympathetic activation, RMSSD and RSA values were inconsistent across the two tasks. These findings are similar to the inconsistent relationship between HRV and self-regulation in the literature and may indicate that different parasympathetic engagement profiles were present across the two tasks which are discussed below.

Although perfectionism did not moderate the amount of effort engaged across the tasks, individual differences in perfectionism did predict self-report items on the difficulty of the parity task and the importance and perception of performance on the d2 task. Furthermore, people high on SOP had increased accuracy on the difficult level of the d2 task but this finding did not coincide with increased physiological effort. These findings have implications for how effort is measured in the perfectionism literature and emphasizes the importance of physiological measurements of task engagement.

**Performance and Self-report Outcomes**

The lack of sympathetic reactivity findings related to individual differences in perfectionism across two tasks suggests that perfectionism may not influence effort measured by physiological reactivity. However, past research has shown that individual differences in perfectionism predict performance outcomes such as accuracy and persistence which are measurements that have been used to represent the construct of effort. Specifically, SOP and related constructs have been related to performance on academics tests and task performance (Accordino et al., 2000; Bieling et al., 2003; Stoeber & Rambow, 2007), and also associated with higher time spent practicing a trade or persistence (Bieling et al., 2003; Mills & Blankstein, 2000; Longbottom et al., 2010). In contrast, SPP and related constructs have not shown a consistence relationship with performance outcomes such as accuracy or task performance (Stoeber & Otto, 2006; Stoeber et al., 2010). The use of behavioral measures to represent effort may be a weakness in the perfectionism literature because physiological and behavioral measures of effort often do not correspond directly. In the current study we found that a discrepancy between performance outcomes and physiological measurements of effort occurred. Specifically, SOP predicted increased accuracy on the d2 task during the most difficult level; however, it did not interact with task difficulty to predict increased effort. The current study suggests that although individual differences in perfectionism may moderate task performance outcomes they might not predict the amount of effort engaged in tasks.

Furthermore, the current study found that SOP and SPP differently predicted perceptions of the tasks which fit within the broader literature of perfectionism but were discrepant from the physiological measures of effort. Specifically, SOP predicted higher ratings on the self-report items assessing how important the task was, how well they thought they did, and how well they thought they did compared to others on the d2 task. Past research has indicated that SOP is associated with higher levels of self efficacy (Frost et al., 1990; Stoeber et al., 2008) and ratings of higher task importance (Besser et al., 2004; Mills & Blankstein, 2000). Moreover, SPP predicted higher ratings on the self-report item assessing the perception of task difficulty on the parity task. This finding fits with past research which found that people high on SPP are more likely to rate tasks as more difficult (Brown et al., 1999). Of note, although SOP was related to higher ratings of task importance, this did not result in higher levels of task engagement as Brehm's motivational intensity theory would predict (Brehm & Self, 1989).

The discrepancy between performance, self-report, and physiological measurements of effort in the current study further highlights the importance of assessing physiological measurements of effort in addition to self-report and behavioral outcomes. Past research on perfectionism suggests that higher achievement is representative of higher effort, however, the current study indicates that people high on SOP may perform more accurately than people low on SOP without trying harder. Furthermore, according to Brehm's motivational intensity theory (Brehm & Self, 1989), higher task importance should result in trying harder on the task, however, this was not apparent in the current study. These discrepancies draw into question past perfectionism research suggesting performance and self-report outcomes indicate effort. It will be important when moving forward with research on perfectionism and motivation that physiological measures of effort are used in addition to self-report and performance outcomes. More extensive measurement of perfectionists' evaluation of tasks, their performance, and their physiological effort may allow for further understanding of the increased likelihood of that perfectionists engage in maladaptive motivational behavior such as procrastinating (Rice, Clarissa, & Dustin, 2012).

However, it is important to note that the lab tasks used in the current study may not have tapped into perfectionistic goals that would draw out individual differences in effort. Although participants in general rated that success on the d2 task was important this did not coincide with the expected sympathetic reactivity trend. This suggests that although people self-reported success on the task as important, it may not have been important enough to engage additional effort during the task. One possibility for this is that self-report of importance of success may be sensitive to demand characteristics. Future studies could use priming techniques to increase the importance of tasks by priming self-relevance or social evaluation (Besser, Flett, & Hewitt, 2004) to elucidate individual differences in perfectionism.

**Secondary Physiological Outcome: Parasympathetic Engagement Profiles**

The current study also examined how parasympathetic activation changed within-person as the d2 task increased in difficulty and also from baseline to task on the parity task. Although the d2 task was not effective in inducing the expected trend of sympathetic reactivity, there was parasympathetic variability. Specifically, the within-person main effect of task difficulty predicted decreased RSA and RMSSD. Parasympathetic reactivity was also apparent during the parity task but in the opposite direction; there was an increase in RSA and RMSSD from baseline to task. HRV (measured by RMSSD and RSA) has been associated with self-regulation (Segerstrom & Solberg Nes, 2007; Fabes & Eisenberg, 1997; Movius & Allen, 2007) and attentional control (Hansen, et al., 2003). However, most studies looking at HRV have examined how baseline HRV correlates with self-regulation and few studies have looked at change in vagal control during tasks. According to Segerstrom and colleagues (2012), a review of the literature on the phasic relationship between HRV and tasks suggests that there are multiple profiles of parasympathetic engagement dependent on the task and the level of stress the task produces. Specifically, a polyvagal explanation of parasympathetic activation suggests that a decrease in HRV is indicative of decreasing vagal control (or "letting off the brake") which allows for an increase in sympathetic activation (Porges, 2007). HRV suppression has occurred across a variety of tasks (Movius & Allen, 2007; Hansen et al., 2003) and has been associated with sustained attention. According to this parasympathetic profile, the results from the d2 task indicate increased HRV suppression as the task got more difficult which suggests people may have increased their sustained attention.

The current study also found a marginally significant interaction with task difficulty and SPP predicting parasympathetic activity (RMSSD). Specifically, people high on SPP had less of a steep slope therefore had less of a decrease in RMSSD values as the task increased in difficulty than people low on SPP. This finding is similar to the decreased HRV suppression that was found in people with social anxiety during a mental arithmetic task (Movius & Allen, 2007). The finding from the current study suggests that people high on SPP may have become increasingly more stressed indicated by less HRV suppression as the d2 task got more difficult. Research indicates that SPP has been related to state anxiety during the completion of tasks and test anxiety (increased introjections and lack of confidence) (Stoeber, Feast, & Hayward, 2009; Flett, Endler, Tassone, & Hewitt, 1994). People high on SPP may be more sensitive to self criticism and worry during tasks which may in turn increase their experience of stress during tasks resulting in decreased sustained attention as evidenced by less HRV suppression.

Furthermore the review by Segerstrom and colleagues (2012) also highlighted evidence of a coactivated profile when both sympathetic and parasympathetic systems are activated which may occur during a task that is both challenging and requires self-regulation. Increases in HRV during mental effort tasks have been found in the literature (Segerstrom & Solberg Nes, 2007; Luft, Takase, & Darby, 2009), however, not many studies have examined both branches of the autonomic nervous system. Silvia and colleagues (2013) found a coactivated profile of the sympathetic and parasympathetic systems similar to the autonomic profile seen in the current study on the parity task. This suggests that the parasympathetic “brake” was being applied while there was also sympathetic activation. Moreover, research indicates that coactivation may be an ideal profile for short term engagement (Koizumi, Terui, Kollai, & Brooks, 1982) therefore participants on the parity task may have been actively engaged during the task.

**d2 Task Timing Parameters**

Unfortunately, the d2 task was not effective in producing the expected pattern of trying and quitting. According to Brehm's motivational intensity theory, if success was important, people should have increased effort as the task got more difficult or should have withdrawn effort when the amount of effort needed did not match the importance of success (Brehm & Self, 1989). The negative quadratic trend found in the current study along with the decreased sympathetic activation found from baseline to the easy level of the task suggests that people in general did not engage effort in the task. The quadratic trend also suggests that people further withdrew effort during the medium level of the task and then reengaged and tried harder during the difficult level of the task. However, these findings are not consistent with previous findings on the d2 task. Previous usage of the d2 task has shown the expected pattern of trying and quitting with both between and within subject changes in a similar sample of college students (Silvia et al., 2014; Silvia et al., 2011). Although the study that used the same timing parameters as the current study was a between person study and therefore these timing parameters may not be effective in capturing within-person change (Silvia et al., 2011). Furthermore, the study that found within-person change used different timing parameters (i.e., only included a difficult level [750 ms] and an impossible level [375 ms]) and experimentally manipulated self-focused attention (Silvia et al., 2014). In terms of the timing parameters of the current study, the easy level of the task may have been too slow/easy therefore people did not initially engage in the task. Moreover, the medium level of the task may not have had enough of a change in timing parameters for people to perceive it as being more difficult and therefore they did not engage additional effort. In addition, the withdrawal of effort on the medium task level may also indicate boredom during the task. Future studies using the d2 task to investigate within-person change in accordance with task difficulty levels should investigate the ideal timing parameters that highlight individual differences in trying and quitting. Furthermore, future studies may want to utilize rest or break periods between the task levels so people do not become bored with the task.

Overall, the findings from the current study provide further support for two parasympathetic activation profiles indicated by Segerstrom and colleagues (2012). However, parasympathetic findings related to mental effort are not clear and can be difficult to interpret in the context of coinciding sympathetic activation. Therefore findings from the current study should be replicated due to the lack of consistent findings in the literature and across both tasks of the study. Furthermore, replication of the d2 task is necessary due to the possible problems with the timing parameters of the task. Future studies looking at sympathetic and parasympathetic activation during mental effort tasks may want to also measure skin conductance to gather additional information about whether the task is stressful which may provide further support for the validity of the parasympathetic profiles (Segerstrom et al., 2012).

The current study highlights the importance of assessing physiological measurements of effort which can provide additional information about task engagement beyond self-report and performance outcomes. Although research suggests individual differences in perfectionism predicts various performance outcomes, the current study indicates this may not be due to differences in mental effort measured by autonomic reactivity. Furthermore, the current study provides support for parasympathetic profiles proposed by Segerstrom and colleagues (2012), however, these findings should be replicated to further clarify whether these profiles represent differences in self-regulation, sustained attention, and stress. In the future, identifying discrepancies between performance, evaluation of performance, and effort may be beneficial for understanding perfectionsts' tendency towards self-defeating behaviors such as procrastinating and self-criticism.

## REFERENCES


Accordino, D. B., Accordino, M. P., & Slaney, R. B. (2000). An investigation of perfectionism, mental health, achievement, and achievement motivation in adolescents. *Psychology in the Schools, 37*(6), 535–545.

Berntson, G.G., Cacioppo, J.T., & Quigley, K.S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology, 30*, 183-196.

Bernston, G.G., Lozano, D.L., & Chen, Y. (2005). Filter properties of root mean square successive difference (RMSSD) for heart rate. *Psyhchophysiology 35*, 246-252.

Berntson, G. G., Lozano, D. L., Chen, Y., & Cacioppo, J. T. (2004). Where to Q in PEP. *Psychophysiology, 41*(2), 333-337.

Besser, A., Flett, G.L., & Hewitt, P.L. (2004). Perfectionism, cognition, and affect in response to performance failure vs success. *Journal of Rational-Emotive & Cognitive Behavior Therapy, 22*(4), 301-328.

Besser, A., Flett, G.L., Hewitt, P.L., & Guez, J. (2008). Perfectionism, and cognitions, affect, self-esteem, and physiological reactions in a performance situation. *Journal of Rational-Emotive & Cognitive-Behavior Therapy, 26*(3), 206-228.

Bieling, P. J., Israeli, A., Smith, J., & Antony, M. M. (2003). Making the grade: The behavioral consequences of perfectionism in the classroom. *Personality and Individual Differences, 35*(1), 163–178.

Blascovich, J., Vanman, E.J., Mendes, W.B., and Dickerson, S. (2011). *Social psychophysiology for social and personality psychology*. London: SAGE Publications Ltd.

Brehm, J.W. & Self, E., 1989. The intensity of motivation. *Annual Review of Psychology, 40*, 109–131.

Brehm, J.W., Wright, R.A., Solomon, S., Silka, L., & Greenberg, J. (1983). Perceived difficulty, energization, and the magnitude of goal valence. *Journal of Experimental Social Psychology, 19*(1), 21–48.

Brickenkamp, R. & Zillmer, E. (1998). *d2 Test of Attention*. Seattle, WA: Hogrefe & Huber.

Brinkmann, K., Schupback, L., Ancel Joye, I., & Gendolla, H.E. (2009). Anhedonia and effort mobilization in dysphoria: Reduced cardiovascular response to reward and punishment. *International Journal of Psychophysiology*,*74*, 250-258.

Brown, E.J., Heimberg, R.G., Frost, R.O., Makris, G.S., Juster, H.R., & Leung, A.W. (1990). Relationship of perfectionism to affect, expectations, attributions, and performance in the classroom. *Journal of Social and Clinical Psychology, 18* (1), 98-120.

Burton, K.D., Lydon, J.E., D'Alessandro, D.U., & Koetsner, R. (2006). The differential effects of intrinsic and identified motivation on well-being and performance: Prospective, experimental, and implicit approaches to self-determination theory. *Journal of Personality and Social Psychology, 91*(4), 750-762.

Chang, E. C. (2006). Perfectionism and dimensions of psychological well-being in a college student sample: *A test of a stress-mediation model. Journal of Social and Clinical Psychology, 25*(9), 1001–1022..

Dunkley, D. M., Blankstein, K. R., Halsall, J., Williams, M., & Winkworth, G. (2000). The relation between perfectionism and distress: Hassles, coping, and perceived social support as mediators and moderators. *Journal of Counseling Psychology, 47*(4), 437–453.

Dunkley, D.M., Zuroff, D.C., & Blankstein, K.R. (2003). Self-critical perfectionism and daily affect: Dispositional and situational influences on stress and coping. *Journal of Personality and Social Psychology, 84*(1), 234-252.

Eddington, K.M. (2013). Perfectionism, goal adjustment, and self-regulation: A short-term follow-up study of distress and coping. *Self and Identity 13*(1-2), 197-213.

Eddington, K.M. & Foxworth, T.E. (2012). Dysphoria and self-focused attention: Effects of feedback on task strategy and goal adjustment. *Journal of Social and Clinical Psychology, 31*(9), 933-951.

Fabes, R. A., & Eisenberg, N. (1997). Regulatory control and adults' stress-related responses to daily life events. *Journal of Personality and Social Psychology, 73*, 1107–1117.

Flett, G.L., Endler, N.S., Tassone, C., Hewitt, P.L. (1994). Perfectionism and components of state and trait anxiety. *Current psychology, 13*(4), 326-350.

Flett, G.L., Russo, F.A., & Hewitt, P.L. (1994). Dimensions of perfectionism and constructive thinking as a coping response. *Journal of Rational-Emotive & Cogntive-Behavior Therapy*, *12*(3), 163-179.

Franzen, J., & Brinkmann, K. (2015). Blunted cardiovascular reactivity in dysphoria during return and punishment anticipation. *International Journal of Psychophysiology, 95*(3), 270-277.

Frost, R. O., Heimberg, R. G., Holt, C. S., Mattia, J. I., & Neubauer, A. L. (1993). A comparison of two measures of perfectionism. *Personality and Individual Differences, 14*(1), 119–126.

Frost, R.O., Marten, P., Lahart, C., & Rosenblate, R. (1990). The dimensions of perfectionism. *Cognitive Therapy and Research, 14*(5), 449-468.

Gendolla, G.H.E. & Richter, M. (2005). Ego-involvement and effort: cardiovascular, electrodermal, and achievement effects. *Psychophysiology 42*(5), 595–603.

Gendolla, G.H.E. and Richter, M. (2010). Effort mobilization when the self is involved: Some lessons from the cardiovascular system. *Review of General Psychology, 14*(3), 212-226.

Gendolla, G.H.E., Richter, M., & Silvia, P.J. (2008). Self-focus and task difficulty effects on cardiovascular reactivity. *Psychophysiology 45*(4), 653–662.

Gendolla, G. H. E., & Wright, R. A. (2009). *Effort*. In D. Sander & K. R. Scherer (Eds.), Oxford companion to the affective sciences (pp. 134–135). New York, NY: Oxford University Press.

Hansen, A.L., Johnsen, B.H., & Thayer, J.F. (2003). Vagal influence on working memory and attention. *International Journal of Psychophysiology*, *48*, 263-274.

Hewitt, P. L., & Flett, G. L. (1991a). Perfectionism in the self and social contexts: Conceptualization, assessment, and association with psychopathology. *Journal of Personality and Social Psychology, 60*(3), 456–470.

Hewitt, P. L., & Flett, G. L. (1991b). Dimensions of perfectionism in unipolar depression. *Journal of Abnormal Psychology*, 100(1), 98–101.

Hewitt, P. L., Flett, G. L., & Ediger, E. (1996). Perfectionism and depression: Longitudinal assessment of a specific vulnerability hypothesis. *Journal of Abnormal Psychology, 105*(2), 276–280.

Hewitt, P. L., Flett, G. L., Turnbull-Donovan, W., & Mikail, S. F. (1991). The Multidimensional Perfectionism Scale: Reliability, validity, and psychometric properties in psychiatric samples. *Psychological Assessment: A Journal of Consulting and Clinical Psychology, 3*(3), 464–468.

Kasser, T., & Ryan, R. M. (1996). Further examining the American dream: Differential correlates of intrinsic and extrinsic goals. *Personality and Social Psychology Bulletin*, *22*(3), 280–287.

Koizumi, K., Terui, N., Kollai, M., & Brooks, C.M. (1982). Functional significance of coactivation of vagal and sympathethic cardiac nerves. *Proceedings of the National Academy of Sciences, 79,* 2116-2120.

Kobori, O., & Tanno, Y. (2005). Self-oriented perfectionism and its relationship to positive and negative affect: The mediation of positive and negative perfectionism cognitions. *Cognitive Therapy and Research, 29*(5), 559–571.

Longbottom, J.L., Grove, R.J., & Dimmock, J.A. (2010). An examination of perfectionism traits and physical activity motivation. *Psychology of Sports and Exercise, 11*, 574-581.

Lozano, D.L., Norman, G., Knox, D., Wood, B.L., Miller, B.D., Emery, C.F., Berntson, G.G. (2007). Where to B in dZ/dt. *Psychophysiology, 44*(1), 113-119.

Luft, C.D., Takase, E., & Darby, D. (2009). Heart rate variability and cognitive function: Effects of physical effort. *Biological Psychology, 82*, 186-191.

Martin, L.L., Ward, D.W., Achee, J.W., and Wyer, R.S. (1993). Mood as input: People have to interpret the motivational implication of their moods. *Journal of Personality and Social Psychology, 64*(3), 317-326.

Mills, J. S., & Blankstein, K. R. (2000). Perfectionism, intrinsic vs. extrinsic motivation, and motivated strategies for learning: A multidimensional analysis of university students. *Personality and Individual Differences, 29*(6), 1191–1204.

Miquelon, P., Vallerand, R.J., Grouzet, F.M.E., & Cardinal, G. (2005). Perfectionism, academic motivation, and psychological adjustment: An integrative model. *Personality and Social Psychology Bulletin, 31*(7), 913-924.

Movius, H.L. & Allen, J.J.B. (2005). Cardiac vagal tone, defensiveness, and motivational style. *Biological Psychology, 68*, 147-162.

Muraven, M. & Slessareva, E. (2003). Mechanism of self-control failure: Motivation and limited resources. *Personality and Social Psychology Bulletin*, *29*(7), 894-906.

Obrist, P. A. (1981). *Cardiovascular psychophysiology: A perspective*. New York, NY: Plenum Press.

Obrist, P. A., Light, K. C., James, S. A., & Strogatz, D. S. (1987). Cardiovascular responses to stress: I. Measures of myocardial response and relationships to high resting systolic pressure and parental hypertension. *Psychophysiology, 24*(1), 65–78.

O'Connor, R.C. and O'Connor, D.B. (2003). Predicting hopelessness and psychological distress: The roles of perfectionism and coping. *Journal of Counseling Psychology, 50*(3), 362-372.

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology, 74*, 116–143.

Riese, H., Groot, P.F.C., Van Den Berg, M., Kupper, N.H.M, Magnee, E.H.B., & Rohan, E.J. (2003). Large-scale emsemble averating of ambulatory impedance cardiograms. *Behavior Research Methods, Instruments, & Computers, 35*(3), 467-477.

Rice, K.G., Richardson, C.M.E., & Dustin, C. (2012). Perfectionism, procrastination, and psychological distress. *Journal of Counseling Psychology*, *59*(2), 288-302.

Richter, M., Friedrich, A., & Gendolla, G.H.E. (2008). Task difficulty effects on cardiac activity. *Psychophysiology, 45*(5), 869-875.

Richter, M. & Gendolla, G.H.E. (2009). The heart contracts to reward: Monetary incentives and preejection period. *Psychophysiology, 46*(3), 451-457.

Schachinger, H., Weinbacher, M., Kiss, A., Ritz, R., & Langewitz, W. (2001). Cardiovascular indices of peripheral and central sympathetic activation. *Psychosomatic Medicine, 63*(5), 788–796.

Segerstrom, S.C., Hardy, J.K., Evans, D.R., & Winters, N.F. (2012). Pause and plain: Self-regulation and the heart. In R.A. Wright & G.H.E. Gendolla (Eds.). *How Motivation Affects Cardiovascular Response: Mechanisms and Applications* (181-198). Washington, DC: American Psychological Association.

Segerstrom, S.C. & Solberg Nes, L. (2007). Heart rate variability reflects self-regulatory strength, effort, and fatigue. *Psychological Science, 18*(3), 275-281.

Sheldon, K.M. and Kasser, T. (1995). Coherence and congruence: Two aspects of personality integration. *Journal of Personality and Social Psychology, 68*(3), 531-543.

Sheldon, K.M. and Kasser, T. (1998). Pursuing personal goals: Skills enable progress, but not all progress is beneficial. *Personality and Social Psychology Bulletin, 24*(12), 1319-1331.

Silvia, P.J., Eddington, K.M., Beaty, R. E., Nusbaum, E.C., & Kwapil, T.R. (2013). Gritty people try harder: Grit and effort-related cardiac autonomic activity during an active coping challenge. *International Journal of Psychophysiology, 88*, 200-205.

Silvia, P.J., Jones, H.C., Kelly, C.S., & Zibaie, A. (2011). Trait self-focused attention, task difficulty, and effort-related cardiovascular reactivity. *International Journal of Psychophysiology, 79*(3), 335-340.

Silvia, P.J., McCord, D.M. & Gendolla, G.H.E. (2010). Self-focused attention, performance expectancies, and the intensity of effort: do people try harder for harder goals? *Motivation and Emotion 34*(4), 363–370.

Silvia, P.J., Moore, L.C., & Nardello, J.L. (2014). Trying and quitting: How self-focused attention influences effort during difficult and impossible tasks. *Self and Identity, 13*(2), 231-242.

Silvia, P.J., Nusbaum, E.C., Beaty, R.C., Eddington, K.M, & Kwapil, T.R. (2014). Effort deficits and depression: The influences of anhedonic depressive symptoms on cardiac autonomic activity during a mental challenge. *Motivation and Emotion, 38*, 779-789.

Stoeber, J., Chesterman, D., and Tarn, T. (2010). Perfectionism and task performance: Time on task mediates the perfectionistic strivings-performance relationship. *Personality and Individual Differences, 48*(4), 458-462.

Stoeber, J., & Eismann, U. (2007). Perfectionism in young musicians: Relations with motivation, effort, achievement, and distress. *Personality and Individual Differences, 43*(8), 2182–2192.

Stoeber, J., Feast, A.R., & Hayward, J.A. (2009). Self-oriented and socially prescribed perfectionism: Differential relationships with intrinsic and extrinsic motivation and test anxiety. *Personality and Individual Differences, 47*(5), 423-428.

Stoeber, J., Hutchfield, J., & Wood, K.V. (2008). Perfectionism, self-efficacy, and aspiration level: Differential effects of perfectionistic striving and self-criticism after success and failure. *Personality and Individual Differences, 45*(4), 323-327.

Stoeber, J., & Kersting, M. (2007). Perfectionism and aptitude test performance: Testees who strive for perfection achieve better test results. *Personality andIndividual Differences, 42*(6), 1093–1103.

Stoeber, J. & Otto, K. (2006). Positive conceptions of perfectionism: Approaches, evidence, challenges. *Personality and Social Psychology Review, 10*(4), 295-319.

Stoeber, J., & Rambow, A. (2007). Perfectionism in adolescent school students: Relations with motivation, achievement, and well-being. *Personality and Individual Differences, 42*(7), 1379–1389.

Weiner, B.A. & Carton, J.S. (2012). Avoidant coping: A mediator of maladaptive perfectionism and test anxiety. *Personality and Individual Differences, 52*(5), 632-636.

Wright, R. A. (1996). *Brehm's theory of motivation as a model of effort and cardiovascular response*. In P. M. Gollwitzer & J. A. Bargh (Eds.), The psychology of action: Linking cognition and motivation to behavior (pp. 424–453). New York, NY: Guilford Press.

Wright, R.A., Killebrew, K., & Pimpalapure, D. (2002). Cardiovascular incentive effects where a challenge is unfixed: demonstrations involving social evaluation, evaluator status, and monetary reward. *Psychophysiology, 39*(2), 188–197.

Wright, R. A., & Kirby, L. D. (2001). *Effort determination of cardiovascular response: An integrative analysis with applications in social psychology*. In M. P. Zanna (Ed.), Advances in experimental social psychology (Vol. 33, pp. 255–307). New York, NY: Academic Press.

APPENDIX A

TABLES

Table 1

Descriptives and Bivariate Correlations

| | ICC d2 | ICC Parity | *M* | *SD* | PEP | RZ | RSA | RMSSD |
|---|---|---|---|---|---|---|---|---|
| PEP | 0.89 | 0.91 | 121.08 | 4.68 | -- | $0.93^{**}$ | $-0.29^{**}$ | $-0.34^{**}$ |
| RZ | 0.87 | 0.91 | 160.93 | 1.70 | | -- | $-0.27^{**}$ | $-0.31^{**}$ |
| RSA | 0.73 | 0.72 | 7.38 | 0.22 | | | -- | $0.88^{**}$ |
| RMSSD | 0.84 | 0.91 | 46.65 | 5.12 | | | | -- |

*Note*. Values in table represent the baseline autonomic values. ICC = intraclass correlation.
$^{**}$ $p <$ 0.01; $^{*}$ $p <$ 0.05 level

Table 2

Within-person Sympathetic Activation on the d2 Task

| | b | *SE* | *p* |
|---|---|---|---|
| Baseline to task x PEP | 1.02 | 0.35 | 0.01 |
| Linear trend x PEP | -0.04 | 0.18 | 0.80 |
| Quad trend x PEP | -0.17 | 0.09 | 0.07 |
| Baseline to task x RZ | 2.35 | 0.64 | <0.01 |
| Linear trend x RZ | 0.01 | 0.29 | 0.97 |
| Quad trend x RZ | -0.30 | 0.12 | 0.01 |

*Note.* Quad = quadratic.

Table 3

Cross Level Interaction of SPP and SOP Predicting the Slope of Task Level Difficulty x Sympathetic Activation on the d2 Task

| | SPP | | | SOP | | |
|---|---|---|---|---|---|---|
| | b | *SE* | *p* | b | *SE* | *p* |
| Linear trend x PEP | 0.11 | 0.21 | 0.60 | -0.26 | 0.20 | 0.19 |
| Quad trend x PEP | 0.06 | 0.10 | 0.51 | 0.13 | 0.13 | 0.33 |
| Linear trend x RZ | 0.18 | 0.35 | 0.60 | -0.02 | 0.35 | 0.96 |
| Quad trend x RZ | 0.15 | 0.14 | 0.27 | 0.06 | 0.15 | 0.71 |

*Note.* Quad = quadratic.

Table 4

Within-person Parasympathetic Activation on the d2 Task

| | b | *SE* | *p* |
|---|---|---|---|
| Baseline to task x RSA | -0.26 | 0.05 | <0.01 |
| Linear trend x RSA | -0.10 | 0.02 | <0.00 |
| Quad trend x RSA | 0.02 | 0.01 | 0.08 |
| Baseline to task x RMSSD | -8.09 | 1.40 | <0.01 |
| Linear trend x RMSSD | -2.07 | 0.64 | <0.00 |
| Quad trend x RMSSD | 0.27 | 0.25 | 0.28 |

*Note.* Quad = quadratic.

Table 5

Cross Level Interaction of SPP and SOP Predicting the Slope of Task Level Difficulty x Parasympathetic Activation on the d2 Task

| | SPP | | | SOP | | |
|---|---|---|---|---|---|---|
| | b | *SE* | *p* | b | *SE* | *p* |
| Linear trend x RSA | 0.04 | 0.03 | 0.24 | 0.02 | 0.03 | 0.52 |
| Quad trend x RSA | -0.00 | 0.02 | 0.91 | -0.03 | 0.02 | 0.10 |
| Linear trend x RMSSD | 1.50 | 0.79 | 0.06 | -0.55 | 0.55 | 0.32 |
| Quad trend x RMSSD | -0.25 | 0.41 | 0.55 | -0.25 | 0.42 | 0.55 |

*Note*. Quad = quadratic.

Table 6

Means, Standard Deviations, and Regressions of SOP and SPP Predicting Performance and Self-report Outcomes on the d2 Task

| | | | SOP | | | SPP | | |
|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | b | *SE* | *p* | b | *SE* | *p* |
| Percent correct on Easy | 0.96 | 0.06 | 0.00 | 0.00 | 0.66 | 0.00 | 0.00 | 0.47 |
| Percent correct on Medium | 0.96 | 0.06 | -0.00 | 0.00 | 0.34 | 0.00 | 0.00 | 0.25 |
| Percent correct on Hard | 0.88 | 0.09 | 0.02 | 0.00 | <0.01 | -0.01 | 0.00 | 0.21 |
| Effort | 5.89 | 1.32 | 0.22 | 0.14 | 0.11 | -0.08 | 0.15 | 0.57 |
| Hard | 3.54 | 1.27 | -0.20 | 0.16 | 0.23 | 0.13 | 0.21 | 0.54 |
| Importance | 5.68 | 1.30 | 0.40 | 0.15 | 0.01 | 0.30 | 0.19 | 0.11 |
| Compared to others | 4.33 | 1.04 | 0.29 | 0.14 | 0.03 | 0.08 | 0.18 | 0.65 |
| Well | 4.67 | 1.19 | 0.33 | 0.15 | 0.03 | -0.13 | 0.19 | 0.11 |

*Note*. Performance and self-report data from the d2 task. (n = 98).

Table 7

Cross Level Interaction of SPP and SOP Predicting the Slope of Time x Cardiac Activation on the Parity Task

| | SPP | | | SOP | | |
|---|---|---|---|---|---|---|
| | b | *SE* | *p* | b | *SE* | *p* |
| Time x PEP | -0.58 | 1.04 | 0.57 | 0.41 | 0.52 | 0.42 |
| Time x RZ | -0.58 | 1.04 | 0.57 | 0.22 | 0.84 | 0.60 |
| Time x RSA | -0.00 | 0.11 | 0.98 | 0.01 | 0.10 | 0.91 |
| Time x RMSSD | 0.48 | 3.12 | 0.88 | -1.52 | 2.55 | 0.55 |

Table 8

Means, Standard Deviations, and Regressions of SOP and SPP Predicting Performance and Self-report Outcomes on the Parity Task

| | | | SOP | | | SPP | | |
|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | b | *SE* | *p* | b | *SE* | *p* |
| Correct | 96.34 | 14.40 | 1.58 | 1.93 | 0.41 | -2.22 | 1.88 | 0.24 |
| Hard | 3.86 | 1.60 | -0.25 | 0.18 | 0.17 | 0.47 | 0.21 | 0.02 |
| Well | 3.78 | 1.45 | 0.11 | 0.15 | 0.47 | -0.29 | 0.18 | 0.27 |

Note: Performance and self-report items for parity task. N = 88 due to people not completing the self-report items for the parity task.

APPENDIX B

FIGURES

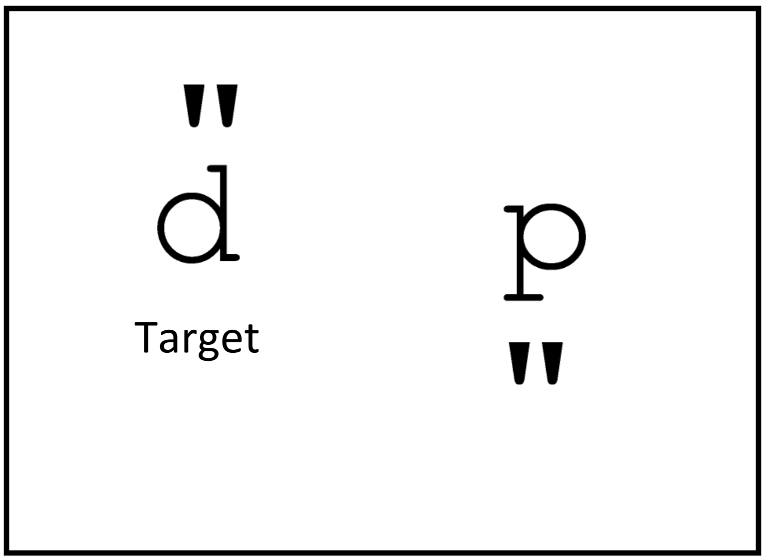


Figure 1. Example of Target and Non-target on d2 Task.

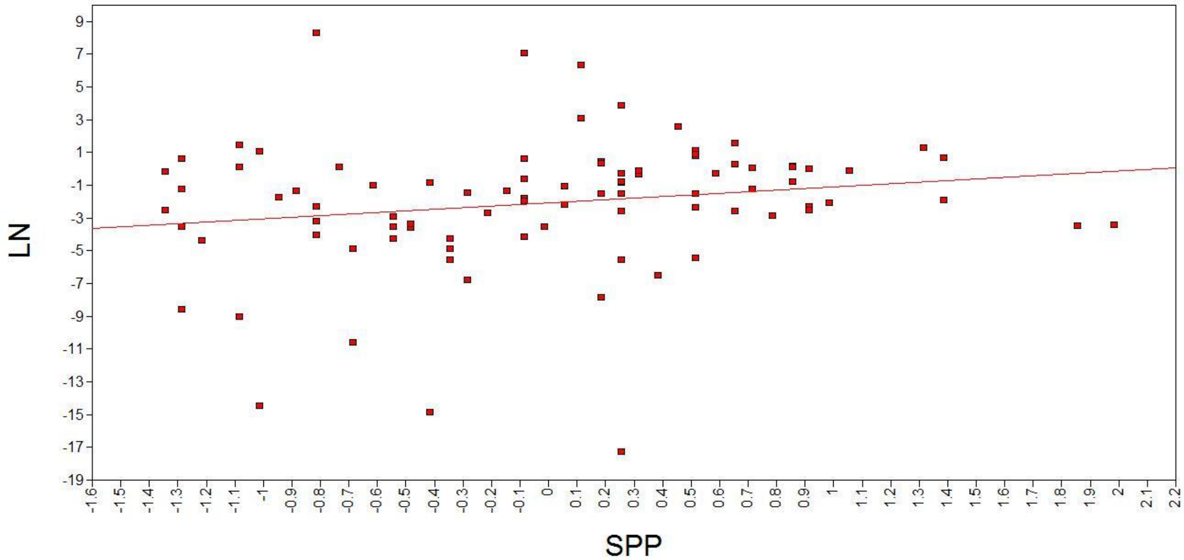


Figure 2. SPP Interacted with the Linear Trend of Task Difficulty and RMSSD During d2 Task. SPP is mean-centered in the model.